artment of Agriculture   Agricultural Research Service   May 1993

Agricultural Research

New Commercial Products From America's Farms

FORUM

Everyday Products Based on Ag Research

In this nation, we're fortunate to have an abundant supply of high-quality food at affordable prices.

In 1991, Americans spent only 11.7 cents of every dollar of disposable, after-tax income on food. It was slightly lower in 1992—11.4 cents, according to preliminary data. This compares with about 22 cents in the 1950's.

There are a lot of reasons for our abundant and affordable food supply, but a key factor—and one that is often overlooked—is the quality of our agricultural science. Behind every product that a farmer produces, there are thousands of hours of research.

Farmers can work from dawn to dusk, but they won't be able to produce enough—at stable prices—if they don't conserve their soil and water, plant hardy varieties, control insects and diseases, and avoid the postharvest spoilage and losses common in many parts of the world.

The impact of research on our supply of agricultural products isn't obvious. We as consumers only see the result.

A few examples that touch our everyday lives illustrate this point. These products aren't limited strictly to food, because our researchers have developed many nonfood uses for agricultural commodities.

Let's begin with frozen foods, starting at the beginning of the day with a glass of orange juice for breakfast. USDA researchers worked closely with fellow scientists from the Florida citrus commission in the mid-1940's to develop a technique for preserving its flavor when reconstituted from concentrate.

If you prefer, say, apple or grape juice, our scientists also developed processes for making those juices from concentrate and techniques to ensure their quality and that they are free from adulteration. In fact, almost any frozen food you eat has ARS' imprint: Our scientists helped spawn the frozen food industry by developing ways to blanch and freeze fruits, vegetables, and other products while retaining their flavor, texture, and nutrients.

Next consider the daily newspaper. In some parts of the country, the ink is based on soybean oil instead of petroleum. Our scientists have developed technology to make its cost more competitive, thereby expanding the use of soybeans.

In early 1991, estimates were that soy-based ink used 5 to 10 million bushels of soybeans yearly. If all U.S. printers converted to 100-percent soy ink, it would consume about 100 million bushels.

Soy ink is good news from an environmental and agricultural standpoint, providing a new use for soybeans and a source of ink from a renewable source.

It's also likely that, in coming years, that newspaper will be printed on paper made from a crop called kenaf, which our scientists have been studying as an alternative source of pulp for paper products. Plans are under way for the first commercial plant to make newsprint from kenaf.

If you are suffering from a bacterial infection such as a sore throat, your doctor might prescribe penicillin or a similar antibiotic. Many Americans don't realize that ARS scientists during World War II developed a technique for mass-producing penicillin so it could be available on a large scale for our soldiers. Our scientists also discovered a more productive strain of the *Penicillium* mold that produces penicillin.

Mashed white potatoes or sweetpotatoes prepared from flakes were brought forth by ARS scientists. And, like our frozen food research, the new technology helped spawn an industry providing nutritious, convenient foods for consumers.

Today, 400 million pounds of potato flakes are produced each year in our country.

If you're having a sandwich for lunch, the bread's quality has been helped by years of research to improve the baking properties of flour. Peanut butter, popular on sandwiches, has better flavor and quality today than it did years ago, partly due to ARS research. If you like sourdough bread, you can thank ARS researchers—in the 1960's they identified the bacterium and yeast that work together to produce the sourdough flavor. Before that discovery, you could only get sourdough bread in the San Francisco area. Now it can be baked anywhere in the world.

These are only a few of the examples of products you might encounter on a given day. It would take too much space to list them all. But, as you can see, ARS is committed to moving our technology from the laboratory into the marketplace.

In 1991 our scientists filed 103 patent applications and licensed 21 inventions to private companies—including a process to grow the cancer-fighting drug Taxol in cell cultures rather than relying on the bark from the scarce Pacific yew tree.

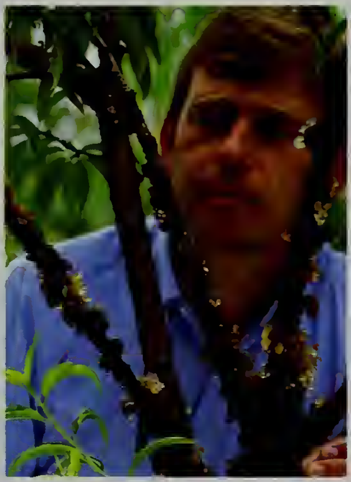
We also signed 59 new cooperative research and development agreements with private companies. If we don't produce a product directly from our research, then often the research is incorporated into a private company's product.

But whether a product is released by ARS or a private company, the important thing is that the product gets to the marketplace, so that the public's tax dollars wind up benefiting the people who paid the bill in the first place.

R.D. Plowman
Administrator

Agricultural Research

Cover: Granules of a starch-encapsulated microbial insecticide shown sticking to a cotton leaf provide long-lasting protection against cotton pests while resisting washoff by rain and breakdown by sunlight. Photo by Keith Weller (K5098-2)



Page 12

Page 17

Page 19

Vol. 41, No. 5
May 1993

Editor: Lloyd McLaughlin (301) 344-2514
Associate Editor: Linda McElreath (301) 344-2536
Art Director: William Johnson (301) 344-2561
Contributing Editor: Jeanne Wiggen (301) 344-2502
Photo Editor: John Kucharski (301) 344-2900
Assoc. Photo Editor: Anita Daniels (301) 344-2956

Reference to commercial products and services is made with the understanding that no discrimination is intended and no endorsement by the U.S. Department of Agriculture is implied.

Agricultural Research is published monthly by the Agricultural Research Service, U.S. Department of Agriculture, Washington, DC 20250-2350.

The Secretary of Agriculture has determined that publication of this periodical is necessary in the transaction of public business required by law.

Information in this magazine is public property and may be reprinted without permission. Non-copyrighted photos are available to mass media in color transparencies or black and white prints. Order by photo number and date of magazine issue.

Subscription requests should be placed with New Orders, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954. Please see back cover for order form.

This publication was printed with soybean oil-based inks.

When writing to request address changes or deletions, please include a recent address label.

Address magazine inquiries or comments to: The Editor, Information Staff, Room 408, 6303 Ivy Lane, Greenbelt, MD 20770

Mike Espy, Secretary
U.S. Department of Agriculture

R.D. Plowman, Administrator
Agricultural Research Service

Robert W. Norton, Director
Information Staff

Industry Consorts With Science

KEITH WELLER

Inset photo: ARS entomologists Robert Gillespie (left) and Michael McGuire (3rd from left) discuss a starch-granule formulation of *Bacillus thuringiensis* on cotton plants with BRDC's Michael Gould (2nd from left) and American Cyanamid's Richard Peevey (right). (K5102-5)

Different colors in these starch granules are caused by additives that protect the encapsulated insecticide and make it more appealing to the target insects. (K5100-6)

On paper, corporate restructuring is a sound business move that trims the fat and sharpens the competitive edge. But many hard-pressed communities across the nation have found corporate restructuring to be synonymous with job casualties.

And so, afflicted communities frantically look for ways to revitalize area businesses, either by retooling existing industries or creating new ones. Many peg their hopes on research and development, two words usually thought to mean progress.

But R&D by itself is no magic bullet. The risks involved in commercializing technology and moving it from laboratory to marketplace are sometimes greater than industry is able to take. These risks include the cost of investment, the inherent slowness of research projects to pay off, and the likelihood that competitors who have not invested will seize hold of the technology before its cost of development is recouped.

Meanwhile, public sector research has problems of its own. "One serious limiting factor is tailoring our research so that it is market driven," says Richard L. Dunkle, director of the Agricultural Research Service's Midwest Area.

But what if there were a way for corporations to reap the benefits of Agricultural R&D without assuming the risks of investment, slow payoff, and proprietary uncertainty? A way for several government scientific arms to participate in technology transfer with a real-world focus? And a way for communities to profit from the synergy that happens when publicly funded research finds its way to the marketplace via commercial development?

In Peoria, Illinois, that's just what's happening, thanks to ARS' cooperation with the Biotechnology Research and Development Corp. BRDC is a for-profit corporation, based at ARS' National Center for Agricultural Utilization Research (NCAUR) in Peoria, that funds research programs at federal and university laboratories.

The original idea called for an agricultural consortium that would investigate fermentation and biotechnologies as potential sources of economic growth in the Peoria area. Business leaders were searching for ways to diversify their industrial base, which was largely reliant on the manufacture of construction equipment.

Five corporations—Dow Chemical Co.; American Cyanamid Co.; Amoco Technology Corp.; Hewlett Packard Co.; and the IMCERA Group Inc.—are shareholders in the development corporation. ARS, the University of Illinois, and Iowa State University are active participants in its research program.

BRDC's rise in the Peoria area was triggered by poor economic times. "We had 17 to 20 percent unemployment," says Del Schneider, chief executive officer of CILCORP Ventures, Inc., and a driving force behind BRDC. "We looked around the community and looked at NCAUR because it already had a good reputation in technology transfer."

The consortium's role is twofold, Dunkle says. It defines those research projects that have market potential and enables industry to enter into high-risk ventures that might otherwise never be undertaken.

Typically it takes 5 to 7 years of research and development to bring an innovation to market, Dunkle says. And, it may take 10 to 12 years before significant licensing revenues are generated.

Reducing risk is what has made BRDC attractive to its corporate shareholders, according to William Dowd of Dow Chemical. In many cases, research programs funded by BRDC dollars probably would never be undertaken by Dow on its own—even though the technology is important, he says.

Each company invests $200,000 per year in BRDC. "[This investment] lets us access $3.4 million in research and play a significant role in directing that research," Dowd says. "You see the real results of the research. You know in real time.

"I think what business gets is cost efficiency," he adds, "plus something money can't buy—time."

KEITH WELLER

Technician Elizabeth Bissett tests the potency of *Bacillus thuringiensis* formulations on European corn borer larvae. (K5101-10)

Tech Transfer—It's the Law

The key ingredient to BRDC's success is a structural change in the ways government and business are permitted to interact. And it took an act of Congress to bring this change about.

"The ultimate success of BRDC could not have been achieved until member companies were allowed to secure exclusive rights to federal technology," says Schneider. So, as the consortium was being formed, Schneider supported critical legislation that Congress would ultimately pass, creating the Federal Technology Transfer Act of 1986.

For the first time, private industry was permitted to enter into contractual agreements with federal labs. The law gave industry an incentive to invest dollars in federal research in exchange for proprietary interest. It allowed federal scientists to share in patent royalties. And it gave consumers access to inventions and discoveries much earlier than otherwise possible.

Putting It All Together

Research proposals submitted for BRDC funding are reviewed by its science advisory board. Board members, two of whom are from ARS, study proposals for market potential and quality. Ideas are drawn from all member companies—ideas that might not otherwise have been considered.

This review by representatives of five or six different companies increases competitive access and often leads to an idea being adopted during development, according to Dowd.

Research projects are basically divided into two categories—those that will offer a new product or service and those that will make a current operation more efficient, he says. In some cases, technology developed under a BRDC grant might be used for unrelated purposes by two or more member companies, says Grant Brewen, president and chief executive officer of BRDC.

"We evaluate research proposals on their commercial potential, and then we do a critical scientific analysis," Brewen says.

ARS has invested about $1.8 million a year over the past 5 years. While ARS doesn't own shares in BRDC, its ability to work with industry and expedite research is greatly enhanced, says Dunkle. The relationship also prevents duplication of previous research, giving taxpayers more for their dollar investment in federal research.

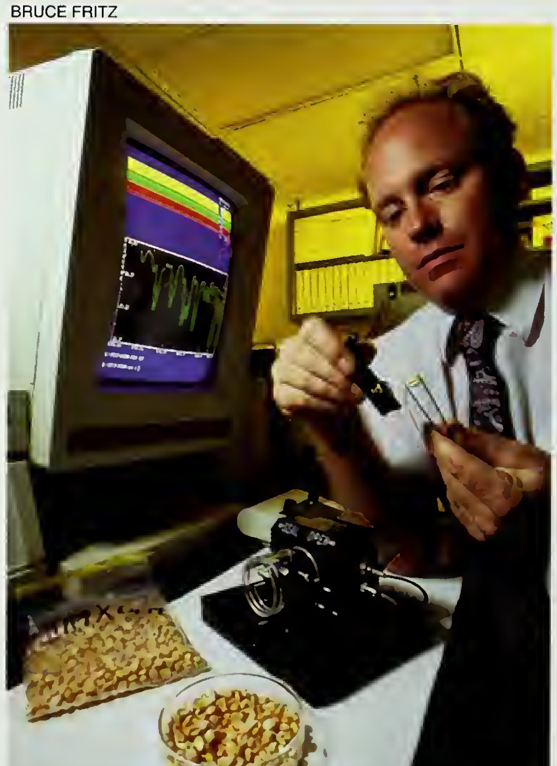
The First Fruits

One of ARS' first BRDC-funded programs deals with a new use for cornstarch in the encapsulation of chemicals and biological pesticides.

"That technology actually started back in 1972," Dunkle says. "Back then industry said 'it really looks good, but it's too expensive.'"

More recently, entomologist Michael R. McGuire and chemist Baruch S. Shasha of NCAUR's Plant Polymer Research Unit looked at various biological controls that can be incorporated in the starch encapsulation technology. A patent application was filed last year and the process has since been licensed to the corporation that in turn sublicensed it to the shareholder companies.

BRUCE FRITZ



ARS biochemist Richard Greene uses a photoacoustic infrared sensor to evaluate corn for fungal contaminants. (K4228-5)

Now it's ready for pilot plant testing to determine the most economical and practical way to produce encapsulated starch-based products. Over the next 2 years, field tests of a number of starch-encapsulated combinations will be conducted in cooperation with USDA in Iowa and Texas.

The technology pinpoints chemical application and improves the efficiency of biological pesticides, such as *Bacillus thuringiensis*, and it should reduce the number and amount of applications needed. This reduces farm operating expenses as it helps safeguard the environment.

The starch-encapsulation process forms granules of pre-cooked cornstarch, insecticide, water, and organic or inorganic chemicals.

Applying granules to crop plants is a snap: They adhere to leaves very well, and insect attractants can also be added to the mixture.

In addition to the original formulation designed to increase the efficacy of the microorganism against the European corn borer, Shasha and McGuire are developing a number of different formulations to target other insect pests.

"We now have four distinct types to enhance the performance of *B. thuringiensis*," McGuire says. "Through our cooperation with the BRDC shareholders, we hope to see products based on this technology on the market in the near future."

Starch encapsulation is one of 21 research projects in which ARS has collaborated with BRDC since it was incorporated in 1988.

Other ARS/BRDC projects include:

• New sources of natural insecticides that could replace petroleum-based chemicals.

Microbiologist Donald T. Wicklow and entomologist Patrick F. Dowd have

KEITH WELLER

Entomologist Michael McGuire checks adhesion of starch granules to a leaf surface. (K5099-14)

identified 75 natural products from the sclerotia of various fungi that may have potential as insecticides. Forty-five of these were previously unknown.

Sclerotia are survival bodies for fungi. They help fungi survive adverse conditions, such as long periods of drought, freezing temperatures, or the absence of a plant or insect host for the fungus to parasitize. Sclerotia of certain plant pathogenic fungi have been shown to survive burial in agricultural fields for up to 10 years.

"The importance of sclerotia to fungal survival suggested to us that compounds produced by sclerotia should provide superior defenses against fungal-feeding insects," Wicklow says.

At first, Wicklow, Patrick Dowd, and J.B. Gloer, a chemist at the University of Iowa in Iowa City, studied sclerotia produced by the fungus *Aspergillus flavus*. One known compound—dihydroxyaflavinine—was found to be effective against the dried fruit beetle. Dihydroxyaflavinine is related to the pigments that cause leaves on trees to turn to brilliant yellows, oranges, and reds in autumn.

"We began looking for other compounds besides dihydroxyaflavinine as potential natural insecticides," Wicklow says. "Our research led to new compounds that work just as effectively against the corn earworm and cotton boll worm as synthetic insecticides."

The researchers are investigating other sclerotium-producing species of fungi besides *Aspergillus* as potential insecticides, he adds.

"There is an urgent need for new sources of insecticides as pests become resistant to existing products," Wicklow says. "It's also important to develop products that are environmentally sound."

Since the research began in 1989, four patents have been issued on the technology and three others are pending, says Curtis P. Ribando, ARS patent application adviser.

• Bacteria, fungi, and plants produce enzymes that can slow the action of certain antiviral drugs, such as those used to treat AIDS and other drugs that activate the body's hormonal system during illness.

These pharmaceuticals would not need to be taken as often if doses were absorbed by the body more slowly, ARS researchers believe.

The enzymes under study attach sugar units to peptides, which are small proteins, to achieve that goal.

"This research could make drugs more stable in the body," says ARS chemist Gregory L. Cote, "and allow more drugs to be taken orally."

• Scientists have developed and are refining infrared sensors to analyze solid materials.

Richard V. Greene, who is in charge of the Peoria center's Biopolymer Research Unit, says the technology could be used to detect fungal contaminants in corn at grain elevators or in industrial processing. This would reduce the risk of natural toxins, such as aflatoxin.

"By using sensors, the disease process can be studied in the intact kernel," says Greene. "This would be an improvement over the typical way to evaluate what is happening in solid materials, which is to destroy the material and then analyze it for compounds."

The sensor study, being done in cooperation with researchers from the University of Illinois, is especially important for studying compounds produced by yeasts and fungi through fermentation.

"Biological materials have complex chemical structures that often exhibit well-defined infrared patterns," Greene says. "These patterns represent the chemical signature of each compound, all of which have distinct traits."

He says this application of the technology is designed to help bioprocessing and fermentation industries monitor microbial growth patterns as well as their production of high-value metabolites, such as antibiotics and vitamins.—By **Bruce Kinzel,** ARS.

For more information about the Biotechnology Research and Development Corp., contact William H. Tallent, USDA-ARS, Room 358A, Administration Bldg., Washington, DC 20250. Phone (202) 720-3973, fax number (202) 720-5427.

ARS scientists mentioned in this article are at the USDA-ARS National Center for Agricultural Utilization Research, 1815 N. University Street, Peoria, IL 61604. Phone (309) 685-4011, fax number (309) 671-7814. ◆

ARS Science Leads to New Business Opportunities

Ask people in Bement, Illinois—ARS technologies really are helping the economies of rural America.

Not only does transferring research findings from federal labs to the private sector provide manufacturing jobs, it has a ripple effect on local economies where the jobs are located.

Six years ago, Central Illinois Manufacturing Co. faced a serious dilemma.

A key ingredient in the fuel filters that they manufactured was no longer available. The ingredient—carboxymethyl cellulose—absorbed water from the fuel. Its primary commercial use had been in feminine hygiene products, but production was discontinued because it was found to contribute to toxic shock syndrome.

At the time, Central Illinois Manufacturing had 65 employees in the eastern Illinois town of 1,800 people. In business since 1964, the company's sales had reached $3.5 million annually.

As William Ayers, president of the firm, embarked on a search for an alternative ingredient, he stumbled across a cornstarch-based absorbent developed by the Agricultural Research Service.

Ayers recalls. "We tried a lot of alternatives, but we chose the starch-based product because it had the best strength."

Today, Central Illinois Manufacturing has boosted its employment to 120 people with an estimated payroll of about $3 million. The company now averages $10 million in sales of fuel filters to most major U.S. oil companies and has markets in Europe and Asia as well.

In Bement, commercialization of an ARS technology is evidenced in the town's business district.

"It's kind of interesting, in a way, because there used to be six vacant buildings in the downtown area," Ayers says. "Because of our success we were able to invest and revitalize businesses. People that never considered buying before in Bement are now. Look how many jobs were created."

A few of the products of other ARS-discovered technologies are listed below.

Product	Company	Location
No-calorie, high-fiber flour	Mt. Pulaski Products Canadian Harvest	Mt. Pulaski, IL Cambridge, MN
Plant virus test kit	Agdia, Inc.	Elkhart, IN
Super-Slurper (starch-derived absorbent material)	Super Absorbent Co. Grain Processing Co. Henkel Corporation	Lumberton, NC Muscatine, IA Kankakee, IL
Traps for stable flies	Tiger Farm Products	Hopedale, MA
Turkey hemorrhagic enteritis virus vaccine	Arko Laboratories Oxford Laboratories Willmar Poultry Co.	Jewell, IA Worthington, MN Willmar, MN
Dietary supplement	Monarch Nutri. Labs	Ogden, UT
Southwestern corn borer pheromone trap	Great Lakes IPM	Vestaburg, MI
Microbial insecticides	Reuter Labs	Haymarket, VA
Controlled bulk vegetable fermentation	Trumark, Inc.	Roseville, NJ
Reducing water content of emulsions, suspensions, and dispersions with highly absorbent starch-containing polymeric compositions	Super Absorbent Co. Grain Processing Co. Worne Biotech Promar, Inc.	Lumberton, NC Muscatine, IA Medford, NJ Milwaukie, OR
Removal of heavy metal ions from waste water	Tetrahedron, Inc.	Stanhope, NJ
Apparatus and method for rapid analyses of multiple samples	Lachat Chemicals Alpkem Corp.	Mequon, WI Clackamas, OR
Novel durable press finishing of textiles	Duro Finishing Corp.	Fall River, MI
Milk-like products from peanuts	Seabrook Blanching	Edenton, NC
Highly absorbent polymeric compositions derived from flour	Illinois Cereal Mills Industrial Services Venture Chemicals Polysorb	Paris, IL Bradenton, FL Lafayette, LA Smelterville, ID
Rope wick applicator	Rear's Mfg. Co. Brothers Equip. Co. BCP Manufacturing Co. Agman, Inc. Rodgers Sales Stanley Resser	Eugene, OR Friend, NV Winters, TX Riverside, MO Clarksdale, MI Weldon, IL
Starch-based semi-permeable films	Uni-Star Industries	Cuba, IL
Recirculating wiper for agricultural chemicals	Apple Machine Co.	Fort Pierce, FL
Biopesticide for stone fruit	Fermenta	Painesville, OH
Marek's disease vaccine	Select Laboratories, Inc. Tri Bio Laboratories	Gainesville, GA State College PA
Biodegradable plastic	Agri-Tech	Peoria, IL

Product	Company	Location
In-ovo vaccination	Embrex, Inc.	Morrisville, NC
Super Slurper dewatering cartridge	Central Illinois Manufacturing Co.	Bement, IL
Turkey semen extender	Continental Plastic Corp.	Delavan, WI
Cotton and soybean seed	Delta and Pineland Seed Co.	Scott, MI
Improved fire ant insecticide	Griffin Corp.	Valdosta, GA
Japanese beetle trap	Consep Membranes	Bend, OR
Direct marketing of fruits and vegetables	Three Rivers Produce	Southeastern, OK
Biochemical and physiological factors influencing turkey egg hatchability	Agrimatic Corp.	Paramount, CA
Improve flavor, texture, and juiciness of processed poultry meat	Continental Grain Co.	Pendergrass, GA
Discover and develop mycoparasites for biocontrol of selected soilborne plant pathogens	Agracetus, Inc.	Middleton, WI
Bee breeding and genetics for bee stock improvement	Weaver Apiaries, Inc.	Navasota, TX
Modification of starch to provide controlled delivery of agricultural chemicals	Illinois Cereal Mills, Inc.	Paris, IL
Cotton gin system design and evaluation to maximize product quality and minimize processing costs	Lummus Industries, Inc.	Columbus, GA
Systems to apply irrigation water efficiently, control intake, and reduce nitrate leaching	Elvert Edgar Oest and Co.	Fruita, CO
Biological control of weeds using exotic and endemic plant pathogens	Confederated Tribes, Coleville Reservation	Nespelem, WA
New engineering concepts for deciduous fruit production, harvesting, sorting	Agri-Tech	Woodstock, VA
Molecular biology of orbiviruses to diagnose and characterize bluetongue virus	Veterinary Diagnostic Technology, Inc.	Wheat Ridge, CO

Product	Company	Location
Vaccination of chicken embryos for protection against avian coccidiosis	Embrex, Inc.	Morrisville, NC
Methods that affect molecular genetic transfer and transformation in crop plants	Pioneer Hi-Bred, Inc.	Johnston, IA
Physiology of agriculturally important spiroplasmas and mycoplasmas	Agdia, Inc.	Elkhart, IN
High-solids tomatoes and low-sugar potatoes using tissue culture	Northrup King Co.	Gilroy, CA
Construction of expression vectors from Marek's disease virus	Select Laboratories, Inc.	Gainesville, GA
Computerized control and management of center pivot irrigation systems	Valmont Industries	Valley, NV
Colonization factors expressed by *Campylobacter jejuni* in chicken	Southeastern Poultry and Egg Association	Decatur, GA
New technologies in cotton ginning	Moisture Systems Corp.	Hopkinton, MA
Integrated strategies for managing filth-breeding flies on dairy farms	Olson Products, Inc.	Medina, OH
Monoclonal antibodies for diagnosis of Marek's disease	Vineland Laboratories Intervet, Inc.	Vineland, NH Millsboro, DE
Development of avian expression vectors using serotypes 1, 2, and 3 of Marek's disease virus	Solvay Animal Health, Inc.	Charles City, IA
Techniques for automated nondestructive quality evaluation of horticultural crops	Process Equipment Co.	Tipp City, OH
Development of methods to protect packaged agricultural products from insect infestation	Trécé	Salinas, CA
Effects of residue decomposition in low-input sustainable agricultural systems	Crops Genetics Intl.	Hanover, MD
Retention of quality of lightly processed fruits and vegetables	Tree Top, Inc.	Selah, WA

KEITH WELLER

Preserving Georgia's Peach Pride

Whether its flesh be white, yellow, orange, or even red as a beet, a Georgia peach can virtually melt in your mouth.

Most fresh-market peaches are what is known as melting freestones, except for the very earliest ripening types. Canning peaches are usually nonmelting clingstones.

ARS plant breeder William R. Okie says that the weather has a lot to do with a peach's delicate taste.

"Dry, sunny days make for an excellent flavor," he says. "A lot of rain or irrigation means they will be more watery and less tasty."

And Okie knows plenty about what makes a good peach. For 13 years, he's been breeding peaches at the ARS Southeastern Fruit and Tree Nut Research Laboratory at Byron—an area in Georgia that has produced peaches for over 150 years.

Since Georgia is the third-largest peach producer in the United States and the Southeast supplies much of the eastern markets with fresh peaches, ARS scientists at Byron are looking for ways to keep the crop healthy and productive.

U.S. growers produced over 2.7 billion pounds of freestone peaches in the 1992 crop year, valued at around $373 million. The Southeast's share of that production was 345.2 million pounds and about $58.3 million.

Breeding New Varieties

Offering growers new peach varieties has been a primary goal since 1937, when USDA began breeding peaches in the heart of the peach-growing area, first at Fort Valley, Georgia, and later at Byron.

New candidates for commercial peach production have to measure up to quality standards. Here, horticulturist W.R. Okie uses a sizing ring on Flameprince. (K4964-13)

The breeding program has produced over 120,000 seedlings, resulting in 32 new varieties, Okie says.

Summerprince is the latest. "It blooms later than most other early-ripening peaches grown in the southeastern states and sets a heavy crop," he explains. "It's also more likely to make a crop in our area than Dixired or Redcap."

Okie started breeding Summerprince in 1980, bringing it to fruit for the first time in 1983. Every year since then, he says, it has produced large crops in Georgia and has looked promising in field tests in Texas and Alabama.

KEITH WELLER

Exposing harvested peaches to UV light helps prevent decay. ARS plant pathologist Lawrence Pusey (left to right) reviews the technique with Tuskegee University's associate professor Clauzell Stevens, research associate Victor Kahn, and professor of food science John Lu. (K4972-2)

Springcrest, an older variety released from Byron by USDA researchers, has been one of the most widely grown peaches in the world, Okie says.

Now, additional effort is going into developing white-fleshed peaches as an alternative crop for growers and a new idea for consumers.

"Sixty years ago, white-fleshed peaches predominated," Okie says, "but firmer, more attractive yellow-fleshed peaches gradually replaced them because they show bruises less readily."

Many Asians and Europeans still prefer peaches with white flesh. Okie thinks that as new, firmer, white-fleshed peaches are released, this market will reappear in the United States.

Brown Rot and Other Fungal Problems

The major disease problem facing peach growers in the Southeast is brown rot. Caused by the fungus *Monilinia fructicola*, brown rot appears on peaches late in the season, just before harvest.

Prevalent throughout the world, this rot attacks all stone fruit but can be controlled with fungicides.

Few effective weapons are available to fight such a formidable foe. Because of potential health and environmental risks, many fungicides have been banned by the U.S. Environmental Protection Agency or have been withdrawn from the market. Benlate, once widely used on peaches, was discontinued for postharvest use about 4 years ago.

ARS plant pathologist P. Lawrence Pusey has some innovative ideas, however. He found a strain of the bacterium *Bacillus subtilis* that controls brown rot on peaches, and he and ARS hold patents on its use against storage rots of various commodities.

ISK Biotech Corporation, Mentor, Ohio, is developing this bacterium for commercial use against rots in peaches, grapes, and bananas.

"*B. subtilis* is a soilborne bacterium that works by producing antibiotics that kill the fungus," Pusey says. "But we're looking for an organism that can be just as effective without the antibiotic."

He has tried several naturally occurring yeasts, but so far, they have not been as good as the bacterium.

"We're looking for an integrated approach, since no single method is likely to replace chemicals entirely," he says. "Possibly an antagonist could be used along with heat treatments, ultraviolet light, reduced rates of chemicals, or substances generally regarded as safe."

Ultraviolet (UV) light is already giving some positive results. Working with Clauzell Stevens, Department of Agricultural Sciences at Tuskegee University in Alabama, Pusey is using low amounts of UV light to increase the resistance in peaches to postharvest storage rots. The research also involves Charles L. Wilson, an ARS scientist at Kearneysville, West Virginia.

"UV light should not be confused with gamma rays. The UV light that we're using is a component of sunlight that plants are not normally exposed to because of ozone screening," Pusey explains.

Collaborator Stevens and Tuskegee colleagues John Y. Lu and Victor A. Khan have been experimenting with this technique for about 8 years.

KEITH WELLER

Plant pathologist P. Lawrence Pusey observes severe peach tree gummosis caused by the fungus, *Botryosphaeria dothidea*. (K4963-6)

In addition to peaches, they have used UV light to reduce black mold and bacterial soft rots of onions; *Fusarium* and *Rhizopus* soft rots of sweet potatoes; black mold, gray mold, and *Rhizopus* rot of tomatoes; and green mold of tangerines.

UV light does not penetrate the peach; it just skims the surface. The positive response to UV light is called radiation hormesis, which is the stimulation caused by low-level exposure to something that would be toxic at higher levels.

"We think the UV hormetic effect triggers a response in the peach that fights off pathogens," Stevens says. "Perhaps the light increases the production of antimicrobial compounds such as phytoalexins."

He says that UV light also seems to delay ripening and increases peach flesh firmness and acidity.

Stevens says that UV light, which leaves no toxic residues, could be used very simply and inexpensively in packinghouse sorting lines.

But Pusey says more research is needed before UV light can be used in commercial systems to prevent storage rots. More study should be given to the effect of UV light in relation to the peach variety, stage of fruit maturity, storage conditions after treatment, and pesticides applied before harvest.

Meanwhile, ARS researchers are searching for an entirely different means of controlling another peach fungal problem. Whereas brown rot attacks the fruit, gummosis attacks the tree itself.

This peach tree disease was first reported in the United States in 1974 in Byron by an ARS scientist. It also occurs in Japan, China, and Australia.

Gummosis causes blisters on the bark of young peach trees in the third year after planting.

"It invades the natural openings in the bark," says Pusey. "Gum then oozes from the resulting lesions."

Overall health of the tree declines; it loses vigor and can die. The causal fungus, *Botryosphaeria dothidea*, spreads when spores are carried by wind or rainwater.

"A control strategy for this disease must include removing deadwood from the orchard, irrigating during periods of drought, and possibly applying fungicides," Pusey says.

He and plant breeder Okie have developed a way to screen young peach trees for resistance, and they've found differing levels among varieties.

Now that they've learned more about peach tree gummosis, Pusey says growers can limit fungicide sprays to the peak infection period in June and July.

Underground War: Nematodes, PTSL, and Oak Root Rot

No part of the peach tree is safe from pest attack. Rots hit the fruit; diseases assault the tree; and nematodes thrive on the roots.

If a young, apparently healthy peach tree suddenly dies in the spring, the ring nematode could be the cause, says ARS nematologist Andrew P. Nyczepir.

"The bark may crack and separate from the tree trunk. The tree can suddenly wilt, give off a sour-sap odor, and then just die shortly after bloom," he says.

This is Peach Tree Short Life (PTSL), induced, Nyczepir says, by thousands of hungry ring nematodes, *Criconemella xenoplax*, feeding on the roots.

All of the tree above the soil line dies, though the main root system below ground looks healthy. But a close inspection shows the feeder roots to be destroyed where ring nematodes have been feeding.

"The trees actually die from cold injury or bacterial canker infection, which result from the parasitic action of the nematode," Nyczepir explains.

A recent survey in South Carolina—the number-two peach-producing state—showed that about 1.5 million trees died from PTSL between 1980 and 1990. This amounted to about a $6.3 million loss per year, just in South Carolina.

Although tree loss varies from year to year, Nyczepir says almost every orchard in Georgia and South Carolina is infested with the ring nematode. And PTSL occurs when the nematode population density and environmental conditions in the spring are just right.

"We've shown that if we can manage the ring nematode, then we can control PTSL," Nyczepir says.

His research shows that the disease occurs only when this nematode is present. PTSL attacks the tree when it is from 3 to 6 years old, just when it starts to bear fruit.

Although chemical control is still used, nematicides are very expensive and may not be available in the near future because of environmental concerns. The cost of preplant fumigation can range from about $275 to $1,300 per acre, depending on which nematicide is used. Presently, only one postplant nematicide is available to growers, and it must be applied twice a year to be effective. It costs about $400

per acre annually and must be used throughout the life of the orchard.

But Nyczepir has found a nonchemical way to thwart the ring nematodes. He takes away their tasty peach roots and gives them Stacy, a variety of winter wheat, to chew on.

"Judging from the reduced count in soil taken from a 3-year test plot, they don't like wheat," he says.

In a PTSL orchard known to be heavily infested with ring nematodes, Nyczepir and cooperators from the University of Georgia removed the peach trees from a large area. Then he used a 1-, 2-, and 3-year rotation system of preplanting wheat/fallow and wheat/sorghum before replanting the plot back to peaches. Rotation decreased the numbers of nematodes significantly. Although some nematodes were still present in the soil, their empty intestines indicated that they had not been feeding.

"Our results show that preplanting Stacy wheat as a nonchemical control before replanting a peach orchard dramatically lowers the nematode population," Nyczepir says.

In another test, peach tree deaths from PTSL were no greater after 2 years in plots previously planted to Stacy than in plots that had been preplant-fumigated with methyl bromide or that were left fallow.

Nyczepir, along with University of Georgia scientists, is also investigating the use of ground-cover grasses as a way to manage the ring nematode.

"We've had good success with two types of bahiagrasses—Pensacola and Tifton 9—that seem to suppress the nematode," he reports.

Peach growers in the Southeast are already following Nyczepir's lead. They are interplanting wheat in their orchards, between the tree rows. Even this, surprisingly, seems to reduce the numbers of nematodes around the tree roots.

There is another way to fight the problem, according to Tom Beckman,

KEITH WELLER

Typical injuries caused by tarnished plant bugs, stink bugs, and the plum curculio. (K4966-7)

KEITH WELLER

Nematologist Andrew P. Nyczepir observes a peach tree stunted by ring and root-knot nematodes. (K4970-6)

horticulturist for rootstock development at Byron.

"We've been looking at peach breeding lines for something that can tolerate PTSL," he says.

Working with Okie, Nyczepir, and researchers at Clemson University, Beckman experimented with more than 100 standard and exotic peach and plum lines on nematode-infested sites in Georgia and South Carolina.

After 10 years, they found one breeding line that showed a significantly longer tree life than Lovell, the peach rootstock commercially recommended for planting in sites that are predisposed to the disease.

In a followup commercial trial now in its fourth season, no trees on this experimental line have shown any injury. But 34 percent of the trees on Lovell and 85 percent on Nemaguard (an alternative commercial rootstock) have already died from PTSL.

Beckman plans a series of full-scale commercial trials throughout the region. One in Georgia and one in South Carolina were established last spring.

"We plan to field-test this line in the fall in Alabama, Arkansas, and Louisiana. If all goes well, we'll formally release the rootstock to growers in the next few years," Beckman says. Until then, a limited amount of seed is available through nurseries for growers interested in trying it.

Although it kills fewer trees than PTSL, oak root rot is another significant problem that afflicts the roots of peach trees. It causes losses of about $4 million each year in South Carolina.

All commercial peach rootstocks are susceptible to oak root rot, Beckman says. And there is no practical control for this disease, which is caused by a soilborne fungus, *Armillaria* spp. One reason, says collaborator Pusey, is that by the time symptoms appear on the tree, it is too late to do anything. The tree is doomed.

KEITH WELLER

Technician Wanda Evans dries peach seeds collected from various rootstock lines. Later, seeds will be grown in field test plots and evaluated for PTSL resistance. (K4959-1)

Since the rot attacks roots, the only treatment would be preplant fumigation of the orchard site. But this is a cost most growers can't afford, especially when they're not sure the rot is present.

"To rid themselves of oak root rot, growers just move their orchards," Beckman says. "But since the pathogen can spread from the roots of hardwood species that are left in the soil after preparation, this practice is only a stopgap measure."

However, Beckman has developed a few plum breeding lines that show some tolerance to the rot. "Our first trials of seedlings of these plums as rootstocks for peaches didn't work because of graft incompatibility," he says. "But we are now testing some new plum/peach hybrids that should offer tolerance to the rot and improved graft compatibility with peaches."

Beckman has propagated other selections from the plum lines by cuttings rather than seed. These appear to be compatible with peaches, he says.

Development of peach rootstocks unaffected by *Armillaria* root rot offers the best hope of preventing losses such as this, according to horticulturist Tom Beckman. (K4958-7)

KEITH WELLER

and are being tested to confirm their resistance to oak root rot and their commercial suitability.

Chemicals Are Important Weapons

Use of pesticides to control insects and some diseases and maintain peach quality is necessary. So ARS scientists at Byron are dreaming up some new ideas for applying those pesticides.

Peaches are planted on a grid with 20-foot-wide rows between the trees in each direction.

"We're spraying just the middle of alternate rows instead of spraying the complete orchard," says Byron entomologist Carroll E. Yonce. "And we're getting control of key early- and mid-season disease and insect pests equal to that of complete spraying."

KEITH WELLER

Alternate row spraying has proven effective in controlling major peach pests. The high-pressure airblast sprayer disperses insecticides throughout the tree, even when directed from just one side. (K4965-11)

Yonce and collaborators at the University of Georgia have been using this technique, which they call ARM (alternate-row-middle), for 2 years. This technique has a two-fold benefit: It cuts in half the amount of chemicals released into the environment, and it cuts growers' costs considerably.

Orchard pesticide applications are made almost entirely by airblast sprayers on each row. Yonce explains. Since concentrated sprays are more efficient and economical than high-volume dilute sprays, most Georgia peach growers use them exclusively for their cover sprays.

The ARM technique takes advantage of the considerable drift from one row to another of pesticides applied by airblast spraying. Therefore, spraying every other row still gives adequate protection.

Some chemicals that are used are long residual. But, since this method allows more frequent spraying, growers can use more short-residual materials.

They are already successfully using the technique.

"We spray alternate rows for the first 6 weeks of the season and get good insect control," says Billy Davidson, who has peach trees on 2,000 acres in Fort Valley, Georgia. He feels more complete coverage is needed after that time since foliage gets so heavy.

Yonce and his colleagues recommend ARM spraying in an integrated pest management program. ARM has been incorporated into the spray guide for Georgia growers.—By **Doris Stanley,** ARS.

Scientists in this article can be reached at the USDA-ARS Southeastern Fruit and Tree Nut Research Laboratory, P.O. Box 87, Byron, GA 31008. Phone (912) 956-5656, fax number (912) 956-2929. ◆

Peach and Nectarine Database

More than 600 peach and nectarine varieties are described in a computer program developed at the Byron laboratory. Included are identifying characteristics, origins, pedigrees, and a master list of thousands of names and synonyms used for peaches and nectarines in North America.

Tall Whitetop's Crowding Out the Natives

The delicate, milky-white flowers of tall whitetop resemble baby's breath and seem the perfect addition to a dried flower arrangement.

But this fast-growing weed actually belongs in the garbage—or better yet, the incinerator.

Tall whitetop—also known as perennial pepperweed—is nothing to sneeze at. It's invaded tens of thousands of acres of pastures, marshes, and riverbanks throughout the West, crowding out desirable native plants. What's more, scientists fear the weed may be poisonous to farm animals.

"All of these people, from ranchers to environmentalists, have been calling their senators, asking them to do something about it," says ARS range scientist James Young.

That's why he and colleagues in ARS' Conservation Biology of Rangelands Research Unit at Reno, Nevada, are busy scrutinizing tall whitetop, hoping to uncover the secret of its success. Detailed knowledge of where it grows, how it spreads, and its other nasty habits should help scientists find a way to stop it.

Research by the University of Nevada's Extension Service and the Nevada Department of Agriculture has shown that 2,4-D helps control the weed. But concerns for fish and other wildlife prevent its use near waterways.

"And young seedlings of willow and cottonwood—the trees that will later shade rivers and provide homes for nesting birds—are sometimes more sensitive to herbicides than tall whitetop is," Young points out.

Grazing livestock may avoid the weed if other forage is available, but they are not so likely to discriminate when tall whitetop contaminates hay harvested from weed-infested meadows.

To find out whether the weed is indeed dangerous for animals to eat, scientists in the ARS Poisonous Plant Research Unit at Logan, Utah, have begun tests.

Other plants related to tall whitetop are suspected of being toxic to horses, according to Lynn James, who heads the Logan lab.

JAMES YOUNG

Tall whitetop. (93-1)

Given a choice, livestock don't prefer tall whitetop, says Young. But they'll eat it, if it's the only green thing around. Because of the recent 6 years of drought in the western United States, that was an increasingly common scenario.

The weed's true identity is a matter of some confusion among scientists, admits Young. Officially, tall whitetop is known as *Lepidium latifolium*. "But we're looking for a European weed expert to confirm the identification," says Young.

Scientists think the weed's seed came to North America accidentally, in a bag of sugar beet seed from Europe near the turn of the century. But tall whitetop has only been considered a pest in the past decade or so.

Today, pastures and prime riparian areas in Nevada and California, once prized for their diverse plant and animal life, are overrun with thick, woody stands of tall whitetop, which grows up to 3 feet high.

In some of the hardest hit areas along the Humboldt and lower Truckee Rivers in western Nevada, native grasses—sedges and rushes that feed grazing livestock and wildlife—were pushed out by the weed.

Alfalfa and sugar beet farmers battle it in California and Nevada.

"It's such an aggressive weed, we think it may produce a substance that repels or even kills nearby plants—a phenomenon known as allelopathy," says Young. Or perhaps tall whitetop somehow disrupts the nitrogen cycle in the soil, making it impossible for other plants to flourish, says Robert R. Blank, also based at Reno.

Because tall whitetop is in the *Cruciferae* family—which includes broccoli, cauliflower, and mustard—finding beneficial insects to control the weed will be difficult. That's because any insect that might feed on tall whitetop may also relish its crop relatives.—By **Julie Corliss**, formerly with ARS.

James A. Young and Robert R. Blank are in the USDA-ARS Conservation Biology of Rangelands Unit, Renewable Resource Center, Room 25, 920 Valley Rd., Reno, NV 89512. Phone (702) 784-6057, fax number (702) 784-1712. Lynn James is with the USDA-ARS Poisonous Plant Research Laboratory, 1150 E. 14th N., Logan, UT 84321. Phone (801) 752-2941, fax number (801) 752-3075. ◆

Lab-Grown Pinkies Cotton to New Fast Food

It's mealtime and you have 5 million hungry mouths—or, in this case, moths—to feed. But a new tactic for whipping up meals for these insects will make cooking for the crowd a whole lot easier. An extruder—a food-processing machine already used to make alphabet noodles for soup or bone-shaped dog biscuits, for example—is ideal for producing fast-food for insects.

Extruders offer a cheaper, faster, and easier way to prepare safe, nutritious food for insects that grow up in a lab, says ARS researcher Richard H. Edwards.

That's good news for entomologists with USDA's Animal and Plant Health Inspection Service (APHIS). They're responsible for raising 700 million healthy pink bollworm moths a year in their Phoenix, Arizona, facility.

Impressed with Edwards' experiments, APHIS is installing a 7-ton, 21-foot-long extruder at its lab. The agency expects to recapture its investment in about 4 years.

The lab-reared pink bollworm moths are put to work in cottonfields of central California's San Joaquin Valley. Pitched from an airplane, the moths drift above the fields, to seek and seduce wild counterparts that have found their way to the valley.

Because the lab moths are sterilized, however, no offspring result from these dalliances.

For the past 22 years, this environmentally friendly approach has successfully kept the pink bollworm, or "pinkie," at bay in central California. Farmers foot most of the bill; in turn, they cut control expenses and avert crop losses, saving an estimated $30 to $60 an acre each year. In the American Southwest, pinkies are cotton's number-one insect enemy.

The sterile bollworm strategy is patterned after the pioneering studies of former ARS researchers Edward F. Knipling and Raymond C. Bushland. The tactic relies on a steady supply of healthy, sterile moths fresh from the lab.

APHIS entomologists raise these insects in 21 days or so from tiny, pearl-white eggs to greyish-brown young adult moths. Extruder-produced food is the only nourishment the growing insects need until they leave the lab, says Edwards, who works at the ARS Western Regional Research Center in Albany, California.

Lab workers using an extruder can turn out more meals for insects in a shorter time than if they used today's kettle-and-tray process, according to Ernest Miller, an APHIS entomologist at Phoenix. The older technology, Miller says, "dates back to the 1970's and requires mixing large batches of food in enormous kettles, then spreading the meals on trays to dry for about a week."

With an extruder, pre-measured raw ingredients—including water, wheat germ, soy flour, preservatives, salts, vitamins, minerals, and gel-like agar—are simply dumped into hoppers that feed into the machine. The extruder mixes, cooks, and sterilizes the food, then presses it into tidbits shaped like pieces of salad macaroni. "It works something like a home breadmaking machine that mixes, kneads, and even bakes the bread for you," says Edwards. "And because all of the steps take place inside the extruder, under very sanitary conditions, there's little chance for bacteria or other contaminants to get at the food."

"With the extruder and some other automation, we can cut our labor costs—our biggest expense—by 70 percent," says Miller.

Preliminary tests that Miller conducted indoors with some 2 million pink bollworm moths indicate that pasta-fed insects are just as healthy and amorous as those raised on food prepared by the kettle-and-tray method.

What's more, Miller expects the extruder will likely triple APHIS' meal-making capacity. That's important, because the agency needs to boost its weekly production by 1994 so that it can offer sterile pink bollworms to cotton growers in other parts of California. "Most people don't realize that California grows about $1 billion worth of cotton every year and usually ranks second or third nationwide in production," he says.

APHIS

Pink bollworm on cotton.

Besides helping to turn out millions of sterile pinkies to protect cotton bolls, Edwards envisions that extrusion processing might speed up foodmaking at labs elsewhere that rear other kinds of sterile insects. Worldwide, about 10 different species of insect pests—the Mediterranean fruit fly, melon fly, gypsy moth, and boll weevil, for example—are mass-reared indoors, then sterilized and set free to foil their outdoor counterparts.—By **Marcia Wood,** ARS.

Richard H. Edwards is in the USDA-ARS Cereal Products Utilization Research Unit, Western Regional Research Center, 800 Buchanan St., Albany, CA 94710. Phone (510) 559-5850, fax number (510) 559-5777. ◆

Rumen Bacteria Rob Cattle of Nutrients

The discovery—and thwarting—of three previously unknown microorganisms in the rumen of cattle could lead to a dramatic decrease in the amount of dietary protein wasted by ruminant animals, says one of the researchers who discovered the bacteria.

ARS microbiologist James B. Russell worked in the late 1980's with graduate students Guangjiong Chen and Herbert J. Strobel to identify the microorganisms. Russell is based at the agency's U.S. Plant, Soil, and Nutrition Laboratory at Ithaca, New York.

According to Russell, the three microorganisms are collectively responsible for wasting up to 25 percent of the protein in cattle diets—a loss of as much as $5 billion annually to cattle producers.

Fortunately, Russell, Chen, and Strobel also identified a possible solution: ionophores, a class of antibiotics approved in 1976 by the Food and Drug Administration as additives to feed for beef cattle and dairy heifers.

Ionophores have not yet been approved for use in lactating dairy cattle.

All three of the bacteria are vulnerable to ionophores such as monensin, a feed additive marketed under the trade name Rumensin.

"The bacteria have no outer membrane to protect themselves from these antibiotics," explains Russell.

When monensin is fed to beef cattle in feedlots, the result is generally an 8 percent improvement in growth efficiency, but the benefit could be twice as great in grazing animals, says Russell.

"The difference in improvement between feedlot and grazing cattle is probably related to protein utilization in the rumen," he says. "Grazing animals are often deficient in protein, even though their protein intake appears to be adequate."

Russell describes the rumen, largest of the four stomach compartments of ruminants, as "a mysterious black box." The activity of microorganisms living there has complicated animal nutritionists' attempts to produce for cattle the same sort of fine-tuned diets that exist for poultry and swine.

"In the ruminant, the microorganisms get first crack at the feed," Russell points out. "Then the animal gets what's left in terms of fermentation products."

Russell hastens to point out that simply wiping out *all* ruminal microorganisms with antibiotics is not the answer, since ruminant animals need the microorganisms and vice versa.

"Without ruminal microorganisms, cattle would not be able to digest cellulose, the material that makes up the bulk of plant cell walls," he notes.

> Three microorganisms are collectively responsible for the waste of up to 25 percent of the protein in cattle's diets—a loss of as much as $5 billion annually.

"Mammals do not make enzymes that break down cellulose. But rumen bacteria can degrade this material, enabling cattle to derive nourishment from eating grass."

Of course, the nation's 100 million cattle eat more than just grass. They also consume about $60 billion worth of feed each year; since high-producing ruminants are usually fed large amounts of feed grains and protein supplements.

But when ruminants consume protein, it is often wastefully degraded to ammonia by ruminal microorganisms. As the protein breaks down, large amounts of ammonia can accumulate in the rumen.

When this occurs, ammonia is absorbed across the rumen wall and is converted to urea by the liver and kidney, to be excreted in urine.

This waste is often less severe for the feedlot animal on a cereal grain diet.

Russell explains, "Rumen microorganisms need nitrogen to grow, and they can use the ammonia as a nitrogen source. Larger numbers of microorganisms in the rumen can use greater amounts of this ammonia and cut down on the waste.

"Since most microorganisms need carbohydrates as an energy source to grow, the starch in cereal grains nourishes the microorganism population and allows it to increase, in turn increasing the ammonia utilization."

Feeding the animals starch to boost their microbial population is not always possible, Russell adds.

"If the cattle are grazing on lush pastures, it may not be feasible for the producer to feed them grain as well," he points out. "So grazing animals often lose more protein than is lost by cattle in the feedlot.

"That's why I believe stopping this protein loss would result in an even greater improvement in feed efficiency for grazing animals than it has for feedlot animals."

Naming the Culprits

For many years, researchers were uncertain as to which ruminal microorganisms were responsible for the rapid rate of ammonia production in the rumen.

By the late 1950's, Marvin P. Bryant, an ARS scientist at Beltsville, Maryland, and his colleagues had isolated the main ruminal bacteria responsible for the various phases of digestion.

In the early 1960's, Bryant studied the capacity of these bacteria to

produce ammonia from protein, and noted that only a few species produced any ammonia.

Based on these results, Bryant concluded that *Bacteroides ruminicola* was usually the most important ammonia-producing bacterium in the rumen of mature cattle.

But when Russell conducted his own experiments at Ithaca in the early 1980's, he found the ability of *B. ruminicola* to produce ammonia simply couldn't account for the amount of ammonia accumulation taking place.

Russell suspected that ruminal protozoa—large, one-celled organisms—might be responsible for the unexplained ammonia output. However, subsequent experiments indicated the protozoa were less adept than the bacteria at ammonia production.

"By the mid-1980's, it had become apparent that the most active ammonia-producing microorganisms had not yet been isolated from the rumen," recalls Russell.

Then in 1987, Russell, Chen, and Strobel isolated a ruminal bacterium that had a 20-fold greater capacity than *B. ruminicola* to produce ammonia.

The following year, Chen and Russell identified two more bacteria with similar capacities for ammonia production.

Because the newly isolated bacteria could not be classified by traditional techniques of bacterial taxonomy, Russell asked Bruce Paster of the Forsyth Dental Center at Boston, Massachusetts, to join the investigation. Together, the Ithaca scientists and Paster identified the bacteria through a relatively new technique: RNA sequencing.

"In the 1970's, it had been determined that bacteria could be genetically classified according to subtle differences in the RNA sequences of their ribosomes, which are particles of RNA and protein found inside cells," Russell explains.

ARS

Microbiologist James Russell found three previously unknown, nutrient-robbing bacteria in the rumen of cattle. (93-2)

RNA sequencing indicated the first bacterium was closely related to *Peptostreptococcus anaerobius*, an organism that had been isolated previously from human clinical specimens, periodontal infections, and feces.

Another of the bacteria proved to be *Clostridium sticklandii,* previously found in soil, San Francisco Bay black mud, and in the feces of a person in Uganda.

The third bacterium, however, did not resemble any bacterial species that had ever been classified. Russell and Paster have proposed the naming of a new bacterial species, *Clostridium aminophilum.*

Once the culprits had been identified, a strategy for counteraction was not long in coming.

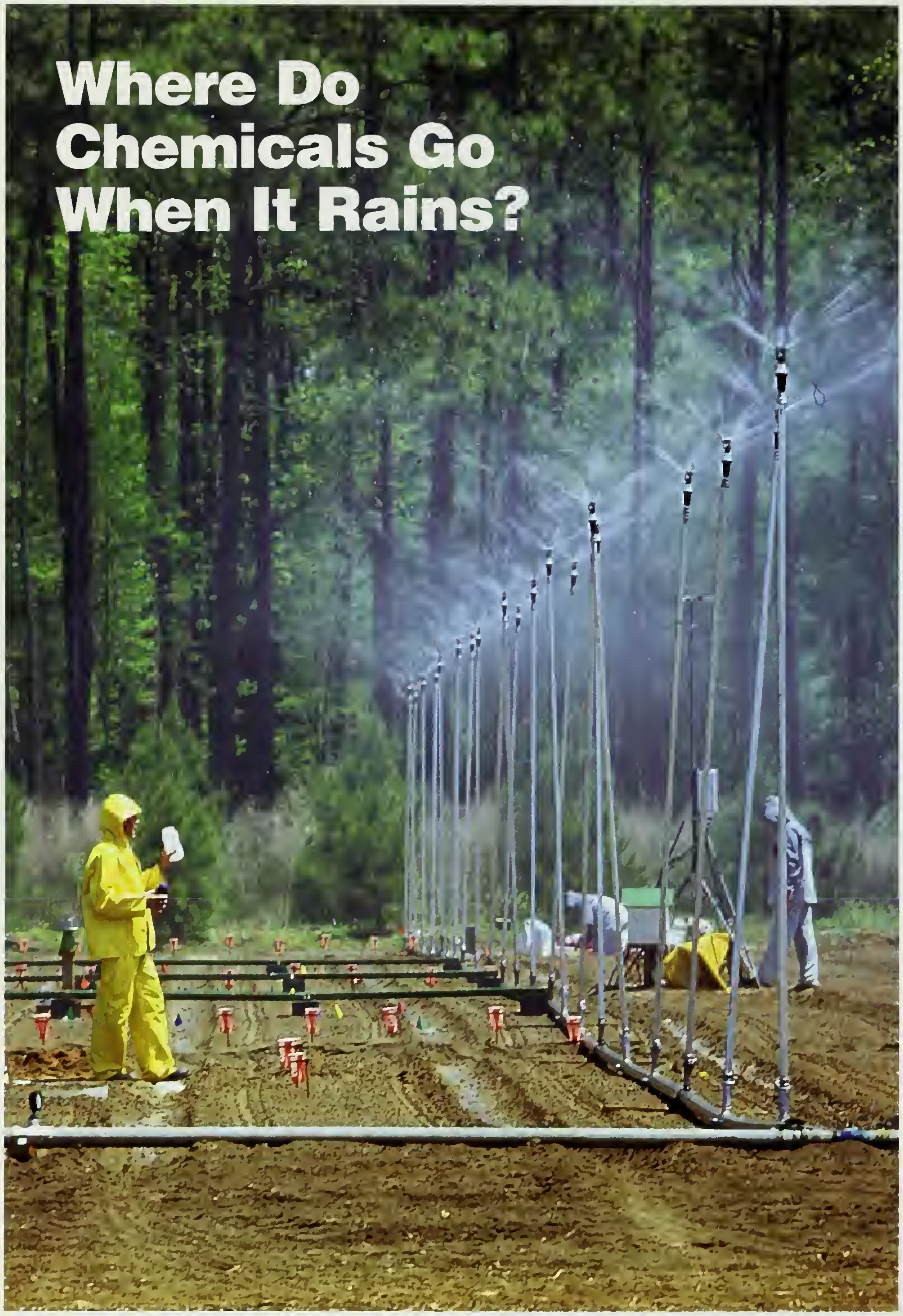
In tests at the Ithaca lab, cattle were fed monensin, the most widely used ionophore. C.M.J. Yang, a nutritionist working with Russell at Ithaca, reported a 50-percent decrease in the steady concentration of ammonia in the rumen of those animals, a 50-percent decrease in the ability of mixed ruminal bacteria to produce ammonia in vitro, and a 10-fold reduction in the numbers of the newly isolated bacteria.

"Based on these results, it appears that the newly isolated ruminal bacteria produce as much as half of the excess ammonia in the rumen," Russell says.

"We're continuing our search for other ways of inhibiting these bacteria, to decrease the wasteful degradation of protein in the rumen."—By **Sandy Miller Hays**, ARS

James B. Russell is affiliated with the USDA-ARS U.S. Dairy Forage Research at Madison, Wisconsin, and is based at the U.S. Plant, Soil, and Nutrition Laboratory, Tower Road, Ithaca, NY 14853. Phone (607) 255-4508, fax number (607) 255-3904. ◆

SCOTT BAUER



Where Do Chemicals Go When It Rains?

Soil scientist Clint Truman (left) collects runoff samples and weather data under simulated rainfall from sprinklers that can apply 2 inches of "rain" in 2 hours. (K5088-18)

A farmer's oft-heard lament is that it always seems to rain at the wrong times. When plants need moisture, the sky is clear. And as soon as fertilizers and pesticides are applied, a downpour comes—just in time to wash them away before they can be effective.

But Don Wauchope and a team of seven researchers in Tifton, Georgia, want it to rain hard soon after they've applied agrichemicals to corn plants on their research plots. In fact, they have set up an overhead irrigation system that can simulate an inch of rain an hour—the type of hard shower that farmers hope to avoid after they've applied pesticides and fertilizers to their crops.

Over a 15-week period last spring from planting to harvest, the researchers created 12 of those heavy rains in the first part of a 2-year study to measure agrichemical runoff. Those rains are yielding a downpour of data for Wauchope and fellow researchers with the U.S. Department of Agriculture and the University of Georgia Coastal Plain Experiment Station in Tifton. The team is analyzing first-year data, and Wauchope says, "It's already clear that we are getting unique and very useful results."

Researchers cooperating in the study are Ben Burgoa, Clyde C. Dowler, A. William Johnson, Laurence D. Chandler, Harold R. Sumner, and Clint Truman, all of USDA's Agricultural Research Service in Tifton; and Jessica Davis-Carter, Gary J. Gascho, and James E. Hook of the University of Georgia Coastal Plain Experiment Station there. Overall, more than 30 people are involved in the project, one of the most intensive runoff experiments ever performed.

The purpose of the research, partially funded by a grant authorized by the USDA National Water Quality Initiative, is to simultaneously measure the movement of water, chemicals, and soil caused by heavy rains. They want to track that movement off crop leaves, as well as into the soil and off the field. While many of the applied chemicals break down and degrade before such rains occur, some can pollute ground- or surface-water supplies if it rains too hard too soon after they are applied.

"The goal is to help water quality agencies better predict agrichemical runoff trouble spots," says Wauchope, an ARS chemist in Tifton. "Once they determine those spots, they can develop strategies for controlling runoff."

Those strategies are important, given the volume of agrichemicals used in American agriculture. In the late 1980's, farmers used an estimated 460 million pounds of herbicides alone each year in the lower 48 states, according to a 1991 report by Resources for the Future, Inc., a private

research firm in Washington, D.C. About two-thirds of that amount is applied to corn and soybeans, according to the report, which was financially supported by USDA, the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration, and four chemical companies. Annual fertilizer use is about 100 billion pounds.

Previous rainfall studies have measured chemical residues in runoff. But, except for small-plot experiments, they have relied on natural rainfall, which can be sporadic. "In our study," Wauchope says, "we're controlling the amount and timing of the rain we apply, so our results are more consistent."

The researchers are copying a technique developed by Pete Coody at Miles Corp., a pesticide manufacturer. The technique allows researchers to simulate rain on a 50- by 150-foot area—big enough to really look at tillage and crop effects.

In the study, seven agricultural chemicals were applied at recommended rates and times, ranging from before planting to crop maturity. They were the nematicide fenamiphos, the herbicides alachlor and atrazine, the insecticide chlorpyrifos, a copper fungicide, and nitrogen, phosphorus, and zinc fertilizers. Also, potassium bromide was used as a tracer.

The researchers planted corn on the plots, which were on a loamy sand with a slope of 3 percent. They measured water moving into the soil and running off the plots for sediment, the four pesticides, pesticide degradation products, and other chemicals and tracers.

The experiment was done simultaneously on large plots, called mesoplots (about 7,500 square feet), and on microplots (about 65 square feet). Wauchope says both were used to determine the effect the size of the plots may have on runoff or erosion.

The rainfall simulator consists of 46 overhead sprinklers spaced 10 feet

SCOTT BAUER

Soil physicist Jim Hook (left) and technician Jody Martin collect water samples gathered by vacuum devices buried in the soil. The water will be analyzed for pesticides and fertilizers carried by percolating rainwater. (K5090-19)

apart in two rows 48 feet apart and running the length of the plots. Runoff water and sediment were collected in v-shaped troughs at the bottom of the slope.

The two herbicides, alachlor and atrazine, are widely used to control weeds, primarily in corn and soybeans. In the late 1980's, 64 million pounds of atrazine and 55 million pounds of alachlor were applied annually on all cropland in the lower 48 states, according to the Resources for the Future report. Wauchope says both herbicides are of special interest because they are being found in trace amounts in rivers, especially in the U.S. Corn Belt.

Fenamiphos, one of the few remaining nematicides allowed for use, is applied to the soil to control nematodes. The insecticide, chlorpyrifos, is applied to crop foliage.

After each chemical treatment, the scientists created a "worst-case scenario" for runoff and erosion—a heavy rainfall 1 day later. Each rainfall poured 2 inches of rain on the test plots over a 2-hour period. Researchers collected the water and soil samples—more than 3,000—and are analyzing the data. The preliminary findings so far show:

• Maximum runoff losses of about one-half inch of water per rainfall event from the mesoplots, decreasing to one-fifth of an inch when the corn was mature. Runoff from the microplots was about twice as much per square foot because the water had less time to infiltrate before reaching the collector troughs than on the larger plots.

• Soil erosion rates of 1 ton per acre on the mesoplots and 1.5 tons on the microplots, in the most erosive rains.

• Herbicide losses of up to 5 percent from the mesoplots and 9 percent from the smaller plots; nematicide losses of 1 percent or less (because it was incorporated into the soil).

• Dissolved phosphorus losses of about 2 pounds per acre for the mesoplots and twice that for the smaller plots for all the runoff events combined.

• Indications that runoff losses for all the other chemicals were much smaller than for the herbicides.

Wauchope says the results for atrazine and alachlor losses are higher than many previous studies indicate, but "we're manufacturing worst-case conditions by making it rain hard only 24 hours after application."

Overall, he says, the study has "demonstrated the ability of these methods to simulate runoff conditions that are not likely to happen, but on which pesticide regulations are based."

He also says EPA and pesticide manufacturers may use the rainfall simulation technology as part of their programs to assess the risk of pesticide movement to water sources. If they do, it could save millions of dollars compared to current field methods, where researchers, like farmers, don't always get the rain when it's needed.—By **Sean Adams,** ARS.

Don Wauchope is in the USDA-ARS Nematodes, Weeds, and Crops Research Unit, Georgia Coastal Plain Experiment Station, P.O. Box 748, Tifton, GA 31793. Phone (912) 386-3892, fax number (912) 386-7225. ◆

Not Too Sweet and Not Too Tart

Most people think of currants as the tiny, dark, dried fruit found in scones or fruitcake. Known as Zante currants, those fruits are actually dried grapes, or raisins.

But true currants are a smooth-skinned, seedy fruit about the size of blueberries. They belong to the genus *Ribes*, whose members include another uncommon fruit, the gooseberry.

Sweet-tart black or red currants are already well known in Europe. And now the fruit can be found in sparkling water and juice blends here in the United States.

Black currants lend beverages a deep purple hue. They also give it a healthy dose of vitamin C—a whopping 2 to 3 times that of orange juice, ounce for ounce.

Most of the currants crushed for juice blends are grown abroad. But because of these potential markets, there's a new interest in growing them here, says Kim E. Hummer. She is curator of ARS' National Clonal Germplasm Repository in Corvallis, Oregon.

The repository houses over 200 different currants, including not just the black and red, but pink and white ones, too. They come from all over the world. Beauty of Altay, for instance, is a black currant from the former Soviet Union, and Gloire de Sablons, a pink currant, came originally from France.

The repository is one in a network of 30 ARS-managed gene banks that safeguard economically important crops and their wild relatives. The Corvallis collection also houses pears, mints, hops, and other small fruits.

One of the most recent currant acquisitions came from high atop a mountain called Popocatepetl, in southern Mexico.

"Because this particular plant grows where there is frost almost every night of the year, it may have unusual hardiness," says Hummer. "We want to see how it will survive in the Pacific Northwest."

Just a few acres of currants are grown commercially in the United States—in Oregon and Washington. England, Scotland, Poland, and a few other countries also cultivate black and red currants, which are used for juices, jams, jellies, and pies.

The berries grow in small clusters on bushes with attractive, lobed leaves. The woody bushes can reach up to 5 feet. Certain ornamental currants sport beautiful spring flowers of white, yellow, maroon, or bright pink. They're found in botanical gardens and arboretums in the western states, as well as backyard gardens, says Hummer.—By **Julie Corliss,** formerly ARS.

Kim E. Hummer is with the USDA-ARS National Clonal Germplasm Repository, 3347 Peoria Road, Corvallis, OR 97333. Phone (503) 750-8712, fax number (503) 750-8717. ◆

Add-On Speedometer Cuts Costs

A new use of an old device, a speedometer, will help farmers more accurately apply the correct amounts of fertilizer and herbicides.

Almost all the error in tractor speedometers occurs because they are attached to the rear drive wheels, which slip when pulling tillage implements. Slippage is desirable because it reduces wear on transmission parts and maximizes draft forces.

But farmers can unintentionally apply too much chemical if they don't realize their tractor speedometers are providing them with inaccurate readings—sometimes as much as 20 percent off. Knowing the accurate speed is critical to keeping the rate of chemical application constant. A tractor moving 20 percent slower than the speedometer reading would apply 25 percent more chemical to a crop area than a tractor moving at the correct speed.

This is not only a waste of expensive chemicals, it also presents potential pollution problems, says ARS agricultural engineer Steven E. Hinkle at the Central Great Plains Research Station, Akron, Colorado.

A speedometer setup he developed eliminates these problems because it is driven off one of the tractor's front wheels, which are usually nonpowered, or freewheeling, and don't slip.

Farmers are trying to cut production costs and increase profits by combining field operations. One combination popular on the Central Great Plains is applying herbicides or fertilizer while sweep tilling.

Sweep tillage is accomplished by using a tractor to pull an implement that has horizontal blades traveling 2 to 3 inches beneath the soil surface. The blades cut roots of growing weeds.

Hinkle constructed the speedometer setup from a commercially available kit that costs about $200 and takes only a couple of minutes to move from one tractor to another. A mounting bracket is built for each tractor and bolted to the front wheel spindle arm. On the hood of the tractor, magnets hold the speedometer display, which can be adjusted so the needle points straight up at the desired speed. As drivers look straight ahead, they merely have to glance at the dial to verify correct speed.—By **Dennis Senft,** ARS.

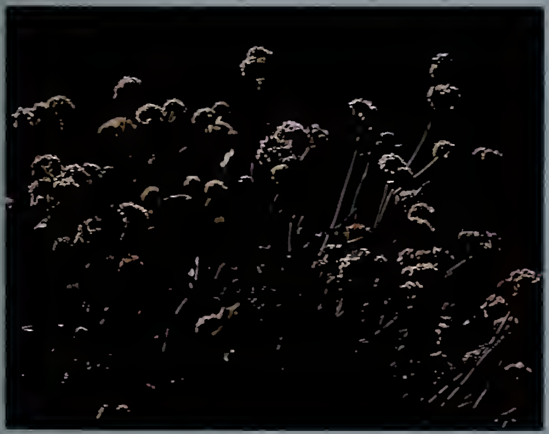
Steven E. Hinkle is at the USDA-ARS Central Great Plains Research Station, P.O. Box 400, Akron, CO 80720-0400. Phone (303) 345-2259, fax number (303) 345-2088. ◆

Science Update

Why Not Guayule?

Up to a half-million Americans may be allergic to latex from the tropical rubber tree. Symptoms range from a minor rash to a rare, life-threatening form of shock. But latex from guayule [why-YOU-lee], a southwestern desert shrub, could be used to make allergen-free surgical gloves, condoms, elastic for clothing, toys, and other products. ARS scientists found that guayule rubber contains very few allergenic proteins. And in preliminary tests by medical researchers, all of the more than 60 volunteers with known rubber-tree latex allergies had no problem with guayule latex. If further tests back up guayule's benefits, this shrub could become a high-value crop. The United States now imports all its natural rubber—about a million tons a year valued at a billion dollars. *Katrina Cornish, Western Regional Research Center, Albany, California. Phone (510) 559-5950.*

ARS



Guayule. (K1559-2)

Lupin Makes Good Food, Feed, and Fertilizer

The crusade for more sustainable agriculture is renewing scientists' and growers' old friendship with lupin. This grain-producing legume makes its own fertilizer and was popular in the Southeast until the 1950's. In recent tests, ARS' old Tifwhite-78 variety yielded up to 60 bushels of lupin grain per acre. Grown as a cover crop and plowed under, it added as much as 200 pounds of nitrogen to the soil. Mainly used as feed grain, lupin is also milled into flour to make tasty, protein- and fiber-rich pasta noodles. *Wayne Reeves, Soil Dynamics Research Laboratory, Auburn, Alabama. Phone (205) 844-3996.*

Get Your Goat!

Roasted or broiled chevon—goat meat—is a lower-fat way to put red meat on the dinner menu. As roast or broiled leg, loin, rack, and shoulder cuts, chevon is 50 to 65 percent leaner than beef and 42 to 59 percent leaner than lamb. Chevon is sold in grocery stores specializing in Asian, Caribbean, Latin American, or Mediterranean foods. *Morse B. Solomon, Meat Science Research Laboratory, Beltsville, Maryland. Phone (301) 504-8713.*

Cross-Species Immunity in Poultry

A new way to protect chickens from coccidiosis may come from their "cousins"—turkeys. When fed parasites that give the disease only to turkeys, chickens not only stayed healthy but became immune to the chicken version of the disease, which costs producers $300 million annually. *Patricia C. Augustine, Protozoan Diseases Laboratory, Beltsville, Maryland. Phone (301) 504-8428.*

African Sorghums May Improve U.S. Varieties

Grain sorghum's ancestral African roots could lead to new varieties tolerant of acid soils. This nutritious livestock food doesn't grow well on highly acid soils common in the eastern United States. But a search of the World Collection of Sorghum in Griffin, Georgia, turned up many acid-tolerant types from Africa. So far, nine have been released to seed companies. *Ralph Clark, Appalachian Soil and Water Conservation Research, Beckley, West Virginia. Phone (402) 472-3654.*

Teen Overweight Can Lead to Adult Health Problems

Parents have a powerful new motive to watch their teenage children's weight: reducing a son's or daughter's risk of disease later in life. While diet, lifestyle, and other factors are important, an ARS-funded study found that men and women who had been overweight as teens were more likely to suffer from heart disease and other ills. And the men, compared to their lean peers, were twice as likely to die earlier. *Aviva Must, USDA Human Nutrition Research Center on Aging at Tufts University, Boston, Massachusetts. Phone (617) 556-3325.*

Cretans Tested for U.S. Whitefly Control

While waiting for their lunch to cook, ever-alert entomologists found potential biocontrol wasps for the sweetpotato whitefly on a vine next to a cafe on the island of Crete. Last year, ARS scientists collected and sent to the United States 17 species of wasps, beetles, and fungi from six countries. The shipments represent the most diverse pool to date of natural enemies that researchers can test against the whitefly. *Alan A. Kirk and Lawrence A. Lacey, European Biological Control Laboratory, Montpellier, France. Phone 33 67 04 56 00.*

U.S. Department of Agriculture
Agricultural Research Service
Room 408
6303 Ivy Lane
Greenbelt, MD 20770

Official Business
Penalty for Private Use $300

To stop mailing ☐
To change your address ☐
Please return the mailing label from this magazine.

Bulk Rate
Postage and Fees Paid
U.S. Department of Agriculture
Permit No. G-95

r1126 03185/20250OSTRJ 4 0001
JESSE OSTROFF
NATIONAL AGRICULTRUAL LIBRARY
ROOM 300B BARC
USDA DELIVERY STOP 20250-1200

Superintendent of Documents Subscription Order Form

Order Processing Code:

6130

Charge your order. It's Easy! MasterCard VISA

To fax your orders (202) 512 2233

☐ **YES**, enter my subscription as follows:

___subscriptions to **AGRICULTURAL RESEARCH** for $28.00 per year ($35.00 foreign).

The total cost of my order is $__________. Price includes regular domestic postage and handling and is subject to change.

Call Order and Information Desk at (202) 783-3238 after 6/30/93 to verify prices.

(Company or personal name) (Please type or print)

(Additional address/attention line)

(Street address)

(City, state, ZIP code)

(Daytime phone including area code)

(Purchase order No.)

May we make your name/address available to other mailers? YES ☐ NO ☐

Please choose method of payment:

☐ Check payable to the Superintendent of Documents
☐ GPO Deposit Account ☐☐☐☐☐☐☐–☐
☐ VISA or MasterCard Account

☐☐☐☐ (Credit card expiration date)

Thank you for your order!

(Authorizing Signature)

Mail To: New Orders, Superintendent of Documents
P.O. Box 371954, Pittsburgh, PA 15250-7954